COMPARISON OF THE RECOVERY STATUS OF BIOCHEMICAL VARIABLES IN THE AEROBIC AND ANAEROBIC CAPACITY OF HOCKEY PLAYERS

SHORT SYNOPSIS

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KHUSHBU SISODIYA
Roll No.- 427
Registration No.- PH2014-05

Under the Supervision of

Lt. (Dr.) BRIJ KISHORE PRASAD

Associate Professor, Department of Health Sciences

Lakshmibai National Institute of Physical Education, Gwalior,

Madhya Pradesh, 474002 - India

DEPARTMENT OF PHYSICAL EDUCATION PEDAGOGY

CERTIFICATE

I hereby declare that the short synopsis **"Comparison of the Recovery Status of Biochemical Variables in the Aerobic and Anaerobic Capacity of Hockey Players"** being submitted in partial fulfillment of the requirement for the degree of Doctor of Philosophy in Physical Education under Department of Physical Education Pedagogy of Lakshmibai National Institute of Physical Education, Gwalior during the academic year 2021- 2022.

It is a bonafide record of original work carried out under the supervision of Lt. (Dr.) Brij Kishore Prasad and has not been submitted in full or part to any other university or institute for a degree or diploma.

(Khushbu Sisodiya)
PH2014-05

19/8/2022

Lt. (Dr.) Brij Kishore Prasad
(Associate Professor)
Head (Department of Health Sciences)

Dr. Krishna Kant Sahu
(Associate Professor)
Dean (Faculty of Physical Education& Allied Areas),
Head (Department of Physical Education Pedagogy)

ABSTRACT

The present research is an in-depth comparative investigation into the recovery status of selected biochemical variables in aerobic and anaerobic capacity in female hockey players. Recovery is a crucial determinant of athletic performance and long-term physiological adaptation, particularly in high-performance sports such as hockey, where both aerobic endurance and anaerobic explosiveness are consistently required. Understanding the distinct biochemical responses and recovery timelines following activities targeting different energy systems provides critical insight into optimising training loads, enhancing recovery, and preventing overtraining or physiological imbalance.

To fulfil the purpose of this study, a total of thirty (30) national-level female hockey players aged 18 to 25 years were purposively selected from the M.P. Women's Hockey Academy, Gwalior. The research design involved assessing each participant under two controlled field-based testing conditions. Aerobic capacity was measured using the Yo-Yo Intermittent Recovery Test Level 1, an established indirect method for estimating VO_2max. Anaerobic capacity was evaluated using the Running-based Anaerobic Sprint Test (RAST), which measures peak power, fatigue index, and short-duration explosive performance.

The selected biochemical markers included: C-Reactive Protein (C-RP) and White Blood Cell (WBC) count as inflammatory markers; Serum Urea and Serum Uric Acid as indicators of metabolic stress; Total Cholesterol (TC), High-Density Lipoprotein (HDL), and Low-Density Lipoprotein (LDL) as components of the lipid profile; and Hemoglobin, Red Blood Cell (RBC) count, and Neutrophil-to-Lymphocyte Ratio (NLR) as hematological and immune system indicators. Biochemical analyses were conducted using standardised laboratory techniques with calibrated instrumentation.

Statistical treatment of the data involved calculating descriptive statistics (mean and standard deviation), followed by inferential analysis using the Independent Samples t-test to determine whether significant differences existed between the biochemical recovery profiles of aerobic and anaerobic capacity. The level of significance was set at $p \leq 0.05$ for hypothesis testing.

The findings of the study revealed that certain biochemical variables, particularly inflammatory and metabolic waste markers, demonstrated elevated values and slower recovery post-anaerobic capacity, suggesting greater physiological strain. Conversely, lipid and hematological markers showed relatively stable behaviour across both capacities, though mild variations were noted. These differences underscore the need for capacity-specific recovery strategies and offer practical implications for sports scientists, coaches, and performance analysts in tailoring post-training protocols.

In conclusion, the study confirms that aerobic and anaerobic capacities impose distinct biochemical recovery demands on elite female hockey players. The research contributes to the existing body of knowledge in sports physiology by highlighting the value of biochemical monitoring in athlete management and by proposing evidence-based guidelines for recovery optimisation. This work supports a more nuanced approach to training design, recovery planning, and injury prevention in elite sports environments.

Keywords: Hockey Players, Female, Aerobic Capacity, Anaerobic Capacity, Recovery Status, Biomarkers

CONTENTS

S.No.	Description	Page No.
1	Introduction	1-4
2	Literature Review	5-9
3	Description of Broad Area	9-11
4	Objectives of the Study	11-15
5	Research Methodology	16-18
6	Expected Outcome of the Research	18-19
	References	20-22

1. INTRODUCTION

"In much of society, research means to investigate something you do not know or understand." **Neil Armstrong**

Exercise Science is an academic and practical subject which deals with scientific study of Physiology, Psychology, Motor Control/Learning, and Biomechanics. Among this all, Exercise physiology: "the study of acute responses of the body to exercise in all its forms and the adaptation of those systems to repeated or chronic exercise, often called exercise training."

The study of exercise and sport physiology involves learning the concepts associated with two distinct exercise patterns. First, exercise physiologists are often concerned with how the body responds to an individual bout of exercise, such as running on a treadmill for an hour or lifting weights. An individual bout of exercise is called acute exercise, and the responses to that exercise bout are referred to as acute responses. When examining the acute response to exercise, we are concerned with the body's immediate response to, and sometimes its recovery from, a single exercise bout. The other major area of interest in exercise and sport physiology is how the body responds over time to the stress of repeated bouts of exercise, sometimes referred to as chronic adaptation or training effects. When one performs regular exercise over a period of days and weeks, the body adapts. The physiological adaptations that occur with chronic exposure to exercise or training improve both exercise capacity and efficiency. With resistance training, the muscles become stronger. With aerobic training, the heart and lungs become more efficient, and endurance capacity of the muscle's increases. (W. Larry Kenney, 2012)

In sports training, stress is a central phase or stage by which the performance of an individual or a sportsperson is enhanced. Every athletic training regimen includes movement and physical exercises that wear you out. Training load directly contributes to fatigue, which aids in the adaption process. Without appropriate tools to speed up the healing process, athletes cannot successfully perform extremely high training loads (Parihar, 2020). Because winning performances are so important in high performance sports, coaches and players are always searching for any advantage that might improve their performance. For a high-performance athlete,

recovery pace and quality are therefore crucial, and effective recovery may offer a host of advantages throughout repeated, intense training and competition. Restoring both the mind and the body is the aim of rehabilitation so that the athlete can train or perform at a level appropriate for them. (Halson S. L., 2018). According to Barry Barnes, Head Coach of Australian Men's Basketball, in his 1996 Atlanta Olympic Report, "The implementation of a rehabilitation program was the single most important component in this team's performance in Atlanta.…" Tour de France Legend Lance Armstrong also remarked, "Recovery is the name of the game. Whoever recovers the fastest does the best". Rest is a common misconception about recovery, but it's much more than that. It is a very crucial part of the training strategy that many amateur athletes are unaware of. Athletes are always looking to train and to find new ways to train to make themselves faster, stronger and better. However, there must be appropriate sports recovery strategies implemented in order for the body to adapt to the training at the high intensity. These strategies are vital to aid the athlete to optimize their training (Sports Recovery Strategies To Improve Your Performance – Part 1). Recovery is emphasized as "recharging an athlete's battery" so that they can compete at their highest level and make the most of their resources. The process of recovering various resources so they may carry on with their operations uninterrupted is known as recovery interventions. (Halson S. L., 2002).

Post-exercise recovery is vital component of the overall exercise training paradigm and essential for high-level performance and continued improvement. If the rate of recovery is appropriate, higher training volumes and intensities are possible without the detrimental effects of overtraining. Recovery may refer to either active or passive recovery. Active recovery comprises continued exercise at a substantially lower intensity or workload, while passive recovery consists of resting completely. The type of recovery to be performed is a consideration for both the time between interval bouts or daily recovery sessions (Dalleck, 2021). The choice of the appropriate recovery modality depends on the activity performed and on the protocol that was adopted (Connolly DA, 2003). Athlete's now-a-days try to find their comfort zone during active recovery, the process called self-paced active recovery.

The idea of a field hockey game between two teams is to use the hockey stick towards the very end of the field to push the ball into the opponent's goal post. There are 11 players on the field, including 10 field players along with a goalie. The game is won by the side with the most points. Worldwide, men and women from various ages participate in this sporadic sport.

Some form of field hockey has been played since ancient times. The sport was brought to Europe through the influence of the Roman Empire. Later the British Empire exposed hockey to their colonies in Asia, Africa, Australia, and America. Today the Federation of International Hockey (FIH) serves as the guardian of the sport. It is responsible for the sport's development and promotion with worldwide national and continental organizations.

An established team sport for both men and women, as well as for children and adults, field hockey is still played on almost every continent. Field hockey, sometimes referred to as hockey globally, combines tactics, strategies, psychological abilities, and physical conditioning. Along with to the physically responsibilities, playing field hockey presents a number of mental and emotional obstacles for players. Although physical size is unrelated to success in field hockey, the successful player needs to quickly and skilfully execute fundamental techniques and use her intelligence and physical prowess, including proper body balance, core muscular strength, anaerobic endurance, flexibility, exceptional hand-eye coordination and ball-to-foot relationship, and agile, speedy movement. It is common for an international player who plays on a watered, swift, artificial surface to run more than 5 miles at a sprint during a 60-minute match (4 quatre) while encountering individual and team problem-solving situations that require coordinated, technical skills. Field hockey players are among the best conditioned of all athletes.

The ATP-PC or Alactacid System- when adenosine triphosphate (ATP) is broken down to form adenosine diphosphate (ADP), energy is given off. Phosphor creatine (PC) is then broken down to creatine and phosphate which then breaks off and bonds with ADP to form ATP again. ATP and PC form naturally in the body and the PC is used to resynthesize quickly. The ATP-PC system provides energy for the shortest duration and only last for about 10-12 seconds. This system is very

important in hockey due to repetitive short bursts of speed and is used 60% of the time.

Anaerobic Glycolysis or Lactic Acid System- it provides energy during high intensity for about 2-3 minutes. Used in the game when players are in the middle of a play, such as a battle for the ball, carrying the ball or chasing the ball. This is generally about 30 seconds to a minute depending on the play. The sprinting involved creates lactic acid build up because glucose is partially broken down in the lower body muscles.

The aerobic system- it is for sustained energy requirements when oxygen is able to be supplied to the working muscles. This system is used of the 20% time in hockey and predominantly used for off the ball movement or when player runs to maintain position.

Since Field hockey is an invasion team sport that entails major aspects of high intensity intermittent exercise therefore it becomes a serious matter of concern to for coaches as well as athletes to look for optimum recovery. The process of recovery allows the body time to repair and strengthen itself in between workouts.

Adequate recovery is based on the normalisation of physiological functions, the restoration of homeostasis, the replenishment of energy reserves, and the replacement of enzymatic cellular energy. Even though generally recovery is associated with a homeostatic recovery process, not only the physiological level of the athlete should be considered, but also the psychological and social level. Therefore, recovery is a physiological, psychological and social process, which is inter-individual in nature, and is orientated towards the recovery of the performance capacities specific to the athlete, i.e., it is an important part of the training process. The effects of (peripheral or central) fatigue should be dealt with, and recovery is considered complete when the player is able to reach or exceed the reference activity. Furthermore, knowing the type of fatigue is essential when identifying the best recovery strategy.(Marqués-Jiménez et al., 2017)

The researcher have gone through several studies and found that overall key points were the identification of best recovery protocols on aerobic and anaerobic capacity for athletes, the best post-recovery intensities at which the recovery rate is maximum.

2. LITERATURE REVIEW

The researchers looked through a variety of sources in an earnest effort to find literature. The following is a list of some significant reviews.

Majumdar et.al. (2008) The present study was taken up to find out the iron status of Indian female hockey players and its changes in six-week training. The iron supplementation was administered to determine the recovery. The experiment was performed on 21 female hockey players age 16 to 26 in the laboratory (25°C and 60% relative humidity). All the parameters were estimated at the initial and final phases of the six-week training camp of six weeks. Iron supplementation significantly ($p<0.01$) improve haemoglobin level, pre and post-test depicts it increases the percentage of certain iron deficiency from 42% to 57%. The players demonstrated high CPK level, LDH found significantly higher ($p<0.05$) when compared to the previous test results. Sudden increase of training load possibly causes muscle hypoxia that results efflux of muscle enzyme CPK and LDH, VO2max, PWC170has shown significant ($p<0.01$) improvement. Iron and TIBC level were found significant ($p<0.01$) in post-test. Iron supplementation improved Hb level but no effect on serum ferritin. High training stresses possibly cause certain iron deficiency. So, it is recommended that female hockey players participating in team sports should be checked regularly for iron and Hb status and CPK/LDH, which is a handy tool to understand overreaching/overtraining.

Conway et. al. (2016) Studied on how a female collegiate athlete's physiology and health respond to training is essential to maintaining fitness and maximizing performance over the course of a demanding competitive season. Training exercises, fitness assessments, and blood-based biomarkers can all be used to evaluate these changes in order to optimize results and enhance athlete management. to assess how fitness and blood-based indicators changed across the course of a women's Division I field hockey season. Before the preseason began and every four weeks after that, biomarker alterations in field hockey players (N = 23) were observed. Before the first preseason practice and 36 hours following a game for T2, T3, and T4, athletes arrived hydrated and famished. Biomarkers associated with stress, oxygen-carrying capacity, metabolism, and nutritional status

were evaluated using blood. Athletes from T1 and T4 reported for performance testing, which included a maximal graded exercise test by direct gas exchange, body composition, and vertical leap. Using the Polar Team2 System, every player was kept under constant observation for signs of training stress during workouts. Based on a competitive field hockey season, these data demonstrate notable variations in training stress and biomarkers. Coaches can assess the stress and recuperation of team training more effectively by integrating blood-based biomarkers into an existing monitoring program.

Manna et. al. (2009) In this study, thirty young Indian field hockey players were used to determine how training affected several physiological and biochemical indicators. An anaerobic and aerobic exercise program was followed for six and twelve weeks, respectively, as part of the training regimen. After the training, a notable increase in anaerobic power and aerobic capacity was seen. Following the training, significant decreases were observed in triglycerides, hemoglobin, total cholesterol, and LDLC. In contrast, following the training, there was a considerable increase in the plasma levels of HDLC, urea, and uric acid. A reduction in body fat and plasma cholesterol levels, together with an increase in HDLC and a drop in LDLC, were seen in the current study, all of which are favorable for improved performance and overall health.

Pal et. al (2017) The conducted study aims to fill the gap in the literature by examining the physiological traits of young field hockey players. 24 male and 24 female field hockey players from the SAI training centre at NSNIS Patiala participated in the study. A shuttle run test lasting 20 meters was administered to the subjects in order to estimate their VO2 max indirectly. To evaluate hockey players' anaerobic power, RAST was used. Significant correlations were found between maximum heart rate, recovery heart rate, and aerobic capacity. Research indicates that males with higher aerobic ability recover their heart rates more quickly in the first minute of recovery.

Glesson (2002) Studied that infection, exhaustion, soreness, or malnutrition can all prevent athletes from giving their maximum effort. A debilitating condition that can impair performance and general well-being for months might result from overtraining without sufficient recuperation time. Advice and instructions about training loads, recovery times, nutrition, and frequent monitoring using appropriate markers should be given to athletes in order to prevent the onset of overtraining syndrome. Overtraining has been associated with objective physiological, biochemical processes, and immunological markers, which have come to light recently. Athletes may benefit from practical markers that are regularly assessed in the lab and provided as part their sports science as well as medical care. Finding commonalities among overtrained athletes could aid in the development of a suitable solution.

Silva et. al. (2022) Blood-based biomarkers, such as cortisol and testosterone, play a significant role in monitoring the catabolic and anabolic status of players, which influences their recovery and aerobic capacity. Changes in hematological parameters, including hemoglobin and C-Reactive Protein (CRP), are linked to players' endurance and recovery processes. The study highlights that monitoring these biomarkers is crucial for understanding players' responses to training and ensuring optimal recovery, thereby enhancing their aerobic performance after the pre-season phase.

Pedlar et.al. (2019) Studied on the use of blood test analysis of data for physiological monitoring and profiling has become increasingly popular in elite and professional high-performance settings. This technique provides important information about red blood cell populations, oxidative damage, inflammation, and dietary deficits. It is feasible to successfully track athletes and assess the effectiveness of their diet and training plans by using longitudinal examination of blood test results. In order to reduce the danger of illness and injury, this method also makes it easier for athletes to modify their nutrition, training schedule, and recovery techniques. Specialized statistical techniques are required to identify changes in athletes' blood test results over time, as typical reference data from the general population may not be sufficient due to the unique biomarker profiles of

athletes. Recognizing that inadequate pre-analytic procedures in sports environments might compromise data quality is important. Additionally, new techniques and technologies that are better suited for athletic uses down the road may be introduced by continuing biotechnology breakthroughs. Concerning blood profiling and tracking for nutrition and performance, this study attempts to provide practitioners in sports science or medicine with up-to-date viewpoints, limits, and recommendations.

Bessa et. al. (2016) The study indicates that blood-based biomarkers, such as the neutrophil/lymphocyte ratio (NLR) and markers of muscle damage like creatine kinase (CK) and lactate dehydrogenase (LDH), can provide insights into an athlete's recovery status after high-intensity exercise. While these biomarkers reflect localized inflammation and muscle damage, they do not directly measure aerobic capacity. However, they can help coaches assess recovery and adjust training intensity, indirectly influencing the athlete's overall performance and aerobic capacity recovery.

Anupal et.al. (2017) This study's objective is to fill a vacuum in literature by describing the physiological features of juvenile field hockey players. The SAI training center at NSNIS Patiala was the site of the study, which involved twenty-four boys as well as girls from the field hockey squad. To assess VO2 max indirectly, the subjects underwent a 20-meter shuttle run test. RAST was used to evaluate hockey players' anaerobic capacity. Aerobic capacity, maximal heart rate, and recovering heart rate were shown to be significantly correlated. It demonstrates that in the first minute of recovery for boys, aerobic ability accelerates heart rate recovery.

Cerqueira et.al. (2020) The present review aimed to clarify the inflammatory effects in response to different exercise intensities. The predetermined inclusion criteria were as follows: a) studies that were observational or interventional; b) that involved healthy people aged 18 to 65; and c) that included moderate to severe activity. Systemic blood levels including cytokines that

leukocytes, creatine Kinase (CK), and C-reactive protein (CRP) were among the particular elements that were investigated. Pro-inflammatory cytokines, specifically IL-6, were found to be elevated, followed by IL-10, which was more noticeable during periods of vigorous activity. Following both vigorous and moderate activity, CRP rose, peaking up to 28 hours later. Only after prolonged and intense exercise did CK rise. Long periods of vigorous exercise may raise inflammatory mediator levels, which may raise the risk of chronic inflammation and damage. The greatest benefits can be obtained from intense or moderate exercise combined with the right amount of relaxation.

3. DESCRIPTION OF BROAD AREA

The broad area of this research lies at the intersection of sports physiology, sports biochemistry, and recovery science, with a specialized focus on female athletes participating in high-intensity, intermittent team sports such as hockey. Sports physiology examines how the body responds and adapts to the physical demands of exercise, encompassing both the immediate (acute) and long-term (chronic) effects of training on the cardiovascular, muscular, and metabolic systems. In the context of hockey, players are required to repeatedly switch between aerobic activities, which rely on sustained oxygen delivery for endurance, and anaerobic bursts, which depend on rapid energy release for sprints, tackles, and quick directional changes. This dual demand places significant stress on multiple physiological systems and necessitates efficient recovery mechanisms to maintain peak performance throughout training and competition.

Sports biochemistry complements this understanding by analyzing the molecular and chemical changes that occur in the body during and after exercise. Key biochemical markers, such as inflammatory proteins (e.g., C-Reactive Protein), metabolic waste products (e.g., urea, uric acid), lipid profiles (cholesterol, HDL, LDL), and hematological indicators (hemoglobin, RBC count, NLR), provide valuable insights into the internal stress and recovery status of athletes. Monitoring these markers allows for the assessment of how different types of exertion impact the body and how effectively athletes are recovering, which is essential for

preventing overtraining, minimizing injury risk, and optimizing adaptation to training loads.

Recovery science, a rapidly advancing field within sports science, delves into the processes by which the body restores homeostasis after physical exertion. It explores the timelines and mechanisms of recovery for both aerobic and anaerobic activities, the role of nutrition, hydration, sleep, and active recovery strategies, and the use of objective biochemical data to guide individualized recovery protocols. For female athletes, this area of research is particularly significant, as hormonal cycles, body composition, and other gender-specific factors can influence both performance and recovery dynamics.

This research seeks to give a comprehensive knowledge of how elite female hockey players adapt to and recover from the particular physiological stressors of their sport by combining these disciplines. Coaches, sports scientists, and medical professionals who want to create training plans based on research, put recuperation plans into action, and promote the long-term health and competitive performance of female athletes must have this expertise. Additionally, it adds to the increasing amount of literature supporting gender-specific sports science research, guaranteeing that the particular requirements and reactions of female athletes are acknowledged and taken into account in both practice and study.

STATEMENT OF THE PROBLEM

The purpose of this research is to compare the recovery status of biochemical variables in the aerobic and anaerobic capacity of hockey players.

RESEARCH QUESTIONS

1. Whether there is a significant difference in the recovery status of selected biochemical variables in aerobic and anaerobic capacity in hockey players?

2. Whether inflammatory markers (C-RP and WBC) recover differently in aerobic and anaerobic capacity in hockey players?
3. Whether metabolic waste markers (Serum Urea and Serum Uric Acid) show a significant difference in recovery between aerobic and anaerobic capacity in hockey players?
4. Whether lipid profile variables (Total Cholesterol, HDL, LDL) recover differently in aerobic and anaerobic capacity in hockey players?
5. Whether haematological markers (Haemoglobin, RBC, Neutrophil/Lymphocyte Ratio) show significant recovery differences in aerobic and anaerobic capacity in hockey players?

4. OBJECTIVES OF THE STUDY

The following objectives were framed:

1. To investigate the difference in recovery status of selected biochemical variables in aerobic and anaerobic capacity in hockey players.
2. To investigate the recovery behaviour of inflammatory markers (C-RP and WBC) in aerobic and anaerobic capacity in hockey players.
3. To investigate the recovery pattern of metabolic waste markers (Serum Urea and Serum Uric Acid) in aerobic and anaerobic capacity in hockey players.
4. To investigate the differences in recovery of lipid profile variables (Total Cholesterol, HDL, LDL) in aerobic and anaerobic capacity in hockey players.
5. To investigate the recovery trends of hematological markers (Haemoglobin, RBC, Neutrophil/Lymphocyte Ratio) in aerobic and anaerobic capacity in hockey players.

DELIMITATIONS

1. The study will be confined to the National-level female hockey players of Madhya Pradesh.

2. The study will be delimited to field hockey players ranging between 18-25 years.
3. The study will further be delimited to a total number of 30 hockey players.
4. The study will further be delimited to the recovery status of aerobic and anaerobic capacity.
5. The study will further be delimited to the following selected biochemical variables-
    a) Inflammatory Marker (C-RP & WBC)
    b) Estimation of Serum Urea.
    c) Estimation of Serum Uric Acid.
    d) Estimation of Serum Total Cholesterol (TC)
    e) Estimation of HD-L (high density lipoprotein cholesterol)
    f) Estimation of LD-L (low density lipoprotein cholesterol)
    g) Estimation of Hemoglobin, RBC.
    h) Estimation of Neutrophils and Lymphocytes Ratio
6. The study is delimited to previous training session.

HYPOTHESIS

On the basis of knowledge gained from available literature, research findings and the scholars own understanding of subject area, the following hypothesis is formulated:

1. There will be a significant difference in the recovery status of selected biochemical variables in aerobic and anaerobic capacity in hockey players.
2. There will be a significant difference in the recovery of inflammatory markers (C-RP and WBC) in aerobic and anaerobic capacity in hockey players.
3. There will be a significant difference in the recovery of metabolic waste markers (Serum Urea and Serum Uric Acid) in aerobic and anaerobic capacity in hockey players.
4. There will be a significant difference in the recovery of lipid profile variables (Total Cholesterol, HDL, LDL) in aerobic and anaerobic capacity in hockey players.

5. There will be a significant difference in the recovery of hematological markers (Haemoglobin, RBC, Neutrophil/Lymphocyte Ratio) in aerobic and anaerobic capacity in hockey players.

DEFINITION AND EXPLANATION OF THE TERMS

Recovery

Period when physical capacity is regained. Physiologically reduced activation level of the body when parasympathetic (vagal) activation dominates the autonomic nervous system over sympathetic activity.

Aerobic capacity

Aerobic training raises maximum aerobic capacity. Both the resting and the workload-specific Vo2 values are constant. The trained muscles are the only ones that undergo the alterations.

Anaerobic capacity

Anaerobic capacity is the maximum quantity of adenosine triphosphate that the entire body can resynthesize through anaerobic metabolism during a particular type of short-duration maximal activity.

Biomarkers

The biological indicator of body internal condition, which can be measured in the blood.

C-Reactive Protein (C-RP)

A protein produced by the liver that increases in response to inflammation. Elevated levels indicate systemic inflammation and are commonly used as a marker to assess tissue damage or infection after physical exertion.

White Blood Cell (WBC) Count

A measure of the number of white blood cells in the blood. WBCs are immune cells, and their elevated count can indicate acute inflammation, stress response, or immune activation following physical capacity (aerobic or anaerobic).

Serum Urea

A waste product formed from the breakdown of proteins and excreted by the kidneys. It reflects protein metabolism and renal function. Elevated levels post-exercise can indicate increased protein catabolism or dehydration during physical capacity.

Uric Acid

A byproduct of purine metabolism. High levels after anaerobic activity may result from increased ATP turnover and muscle stress. It serves as an indicator of oxidative stress and recovery efficiency.

Total Cholesterol

The total amount of cholesterol in the blood, including HDL, LDL, and other lipid components. It reflects the overall lipid status and cardiovascular risk and may fluctuate due to exercise-induced metabolic shifts

HDL (High-Density Lipoprotein)

Known as "good cholesterol." It helps remove excess cholesterol from the bloodstream and transport it to the liver for excretion. Higher levels are generally favorable and can increase with regular aerobic capacity.

LDL (Low-Density Lipoprotein)

Referred to as "bad cholesterol" due to its role in plaque buildup in arteries. It may decrease with consistent aerobic training but can vary in response to anaerobic activity or recovery status.

Haemoglobin

A protein in red blood cells that carries oxygen from the lungs to body tissues. It reflects oxygen-carrying capacity and aerobic endurance potential. Fluctuations may indicate hydration status or hemoconcentration post-activity.

Red Blood Cell Count (RBC)

The number of red blood cells in the blood. Important for assessing the body's ability to transport oxygen. It can be affected by intense training or recovery mechanisms.

Neutrophil/Lymphocyte Ratio (NLR)

A derived marker from WBC count that reflects systemic inflammation and stress. An elevated NLR post-exercise indicates immune system activation and can be used as a sensitive marker for recovery status and inflammation following different physical capacities.

SIGNIFICANCE OF THE STUDY

The study may significant in the following ways-

1. The results of the study will add scientific information to existing knowledge in the field of research of physical education and sports sciences in general and particularly in game field hockey.
2. This study will help the use of physiological and biomarkers can improve a coach's ability to assess the recovery period after an exercise session and to establish the intensity of subsequent training sessions.
3. This study will assist coaches, sports specialists, researchers, and athletes in better understanding how to completely monitor physiological changes while designing sessions of training that induce maximum performance increases while reducing overtraining and injury risk.

5. RESEARCH METHODOLOGY

PROCEDURE

In this chapter the selection of subjects, selection of variable, criterion measures, administration of test, collection of data and statistical technique will be described.

SELECTION OF SUBJECTS

To achieve the purpose of this study, 30 (Female) subjects age ranging 18-25 years. Female National Level Hockey Players will be select purposively, from M. P. women's hockey academy Gwalior.

SELECTION OF VARIABLES

1. Biochemical variables-
    a) Inflammatory marker (C-RP & WBC)
    b) Estimation of Serum Urea.
    c) Estimation of Serum Uric acid.
    d) Estimation of Serum Total Cholesterol (TC)
    e) Estimation of HD-L (High Density Lipoprotein Cholesterol)
    f) Estimation of LD-L (Low Density Lipoprotein Cholesterol)
    g) Estimation of Hemoglobin, RBC.
    h) Estimation of Neutrophils and Lymphocytes Ratio
    i)

CRITERION MEASURES

The criteria that will be used in the present study are:

1. VO_2max (peak oxygen uptake) for measuring the aerobic capacity. Assessment of maximum aerobic capacity (VO_2max) – indirect method is adopted: YO-YO intermittent Recovery test (YYIRT1)
2. RAST (Running-based anaerobic sprint test) field-based test which provides measurements of power and fatigue index (for measuring the anaerobic capacity).

3. Biochemical variables are examined through the laboratory blood sample test.

ADMINISTRATION OF TEST

For the study, the participants will be advised to avoid heavy sessions for 2 days prior to testing. The participants will be asked to assemble on a synthetic hockey field, and before starting the session, they will do proper warming up. The basic information, like age, height, weight, and training age of the subjects, will be collected.

PROCEDURE FOR COLLECTION OF DATA

The data will be collected according to different tests:

1. The Yo-Yo test is an indirect measurement of VO_2max test
    a) In this test subject has to run between two marking cones placed 20 meters apart, at increasing speeds, until exhaustion.
    b) To estimate the athletes VO_2 max from the results of the Yo-Yo tests, use the formulas below:
    c) Yo-Yo intermittent recovery test level 1: VO^2 max ($mL*kg^{-1}*min^{-1}$) = total distance (m) x 0.0084 + 36.4
2. Running based Anaerobic Sprint test (RAST) is a field-based test which provides measurements of power and fatigue index.
    - Mark a 35-meter straight running distance using cones on a flat, non-slippery surface (indoor court or athletic track preferred).
    - Instruct the subject to perform six (6) maximal sprints over the 35-meter distance. Each sprint must be run with maximum effort.
    - After each sprint, allow exactly 10 seconds of passive recovery. The subject remains stationary and prepares for the next sprint during this rest period.
    - Record the time taken for each sprint using a digital stopwatch or electronic timing gates. Ensure timing starts at the subject's first movement and stops when they cross the finish line.

- Repeat the sprint–rest cycle six times to complete the full RAST protocol.
- Ensure all six sprint times are accurately documented on a data recording sheet for each subject.
- After completion, allow the subject to perform a cool-down session consisting of light jogging and stretching.

3. The selected biochemical variable will be measured in the laboratory at the end of testing phase. Each test was scheduled at the same time of day (±1 hour) in order to minimize the effect of diurnal variation. The subjects were informed about the possible complications of the study and gave their consent.

STATISTICAL TECHNIQUE

In this study initially the mean and standard deviation will be used as descriptive statistics. In the second phase independent t-test will be used to determine the significant difference in groups. The level of significance will be kept at 0.05 to test the hypothesis.

6. EXPECTED OUTCOME

The expected outcome of this study is to provide a detailed understanding of the differing biochemical recovery responses following aerobic and anaerobic exercise in elite female hockey players. It is anticipated that markers of inflammation, such as C-Reactive Protein and White Blood Cell count, as well as metabolic waste indicators like serum urea and uric acid, will show significantly higher elevations and slower recovery after anaerobic activity compared to aerobic exercise, indicating greater physiological stress and a prolonged recovery period following high-intensity, short-duration efforts. In contrast, lipid profile components-including total cholesterol, HDL, and LDL-and hematological markers such as hemoglobin, red blood cell count, and neutrophil-to-lymphocyte ratio are expected to remain relatively stable, with only minor or non-significant fluctuations between the two types of exertion. These findings will emphasize the importance of implementing capacity-specific recovery strategies, suggesting that more

focused and intensive recovery interventions are necessary after anaerobic-dominant sessions. Ultimately, the study aims to offer evidence-based recommendations for coaches, sports scientists, and support staff to optimize training loads, enhance recovery processes, and minimize the risk of overtraining or physiological imbalance in elite female hockey players. By contributing valuable insights into biochemical monitoring and recovery optimization, this research will support the development of tailored training and recovery protocols that promote both peak performance and long-term athlete health.

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